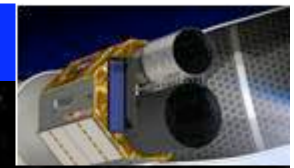
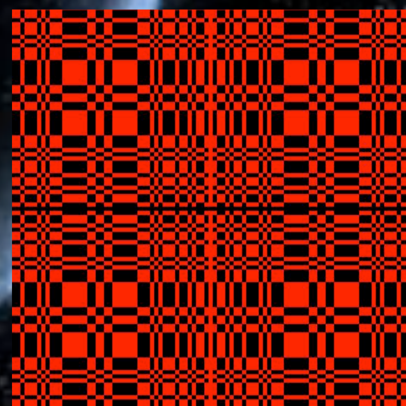


Hunting the "*good*" GRBs for Xenia

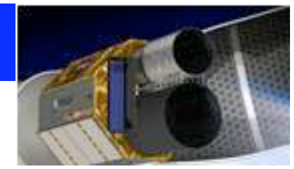
Lorenzo Natalucci and Pietro Ubertini

On behalf of the EDGE/WFM and Xenia/TED Teams



Xenia/TED project is currently developed by INAF and GSFC

Background Image: EPA/Nasa

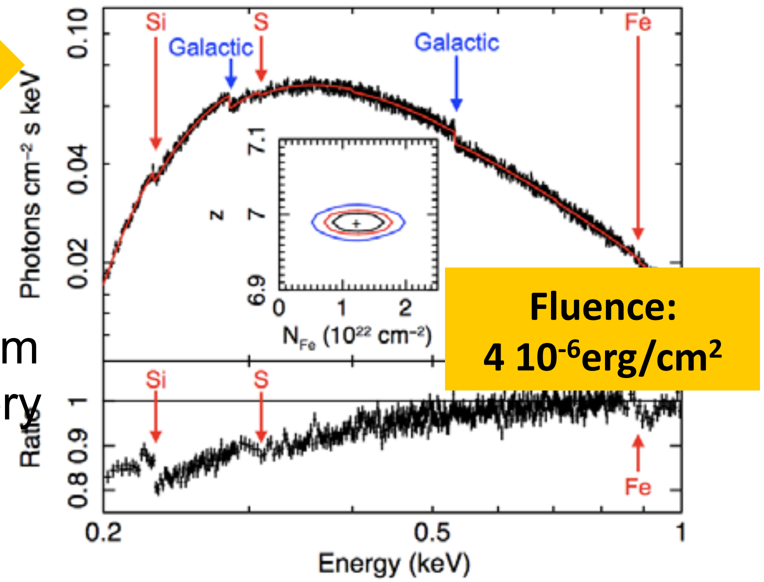


A brief history of the concept

GRBs are used by Xenia as beacons for WHIM in absorption

On Xenia, the **TED** is required to locate a sufficient number of GRBs with afterglows bright enough for the **HARI** and **CRIS** instruments to determine the absorption from the WHIM and to measure the cosmic history of metals at GRB sites

Simulated spectrum of a z=7 GRB afterglow

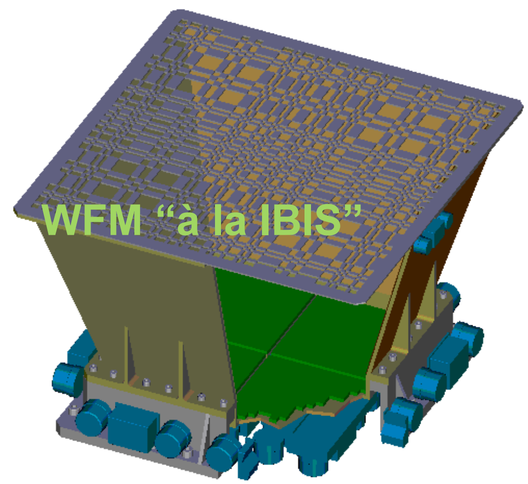


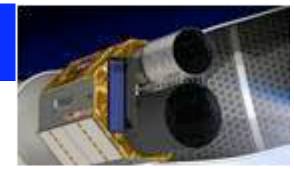
- ❑ **the basic questions:**

How many GRBs do we need? How much bright?

- ❑ **the answer: Detect and localize >50 GRB per year greater than ~10^{-6} erg cm^{-2}**

This translates for the TED to have effective area > ~ range ~10-150 keV, omnidirectional within a FOV of ~





A CZT imager as Transient Events Detector

Why CZT:

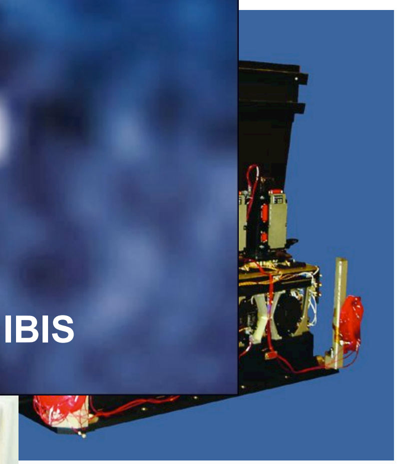
1) **The heritage of *INTEGRAL* and Swift**:

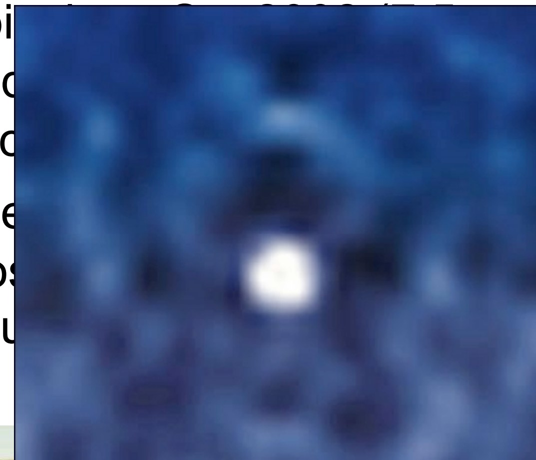
2) **The good performance of CdTe/ CZT** as large area detection devices:

- well known and space proven technology
- good efficiency in the hard X-ray range
- stable and long duration equipments, very suitable for space
- relative ease of manufacturing for large detections areas
- good imaging capability as pixilated system

IBIS is in orbi rs), all subsystems (c Units and Electronic

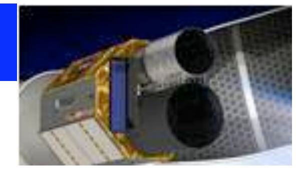
- No equipme have been los usage of redu parts





GRB 021125 by IBIS
(courtesy ESA)

IBIS/ISGRI Detector

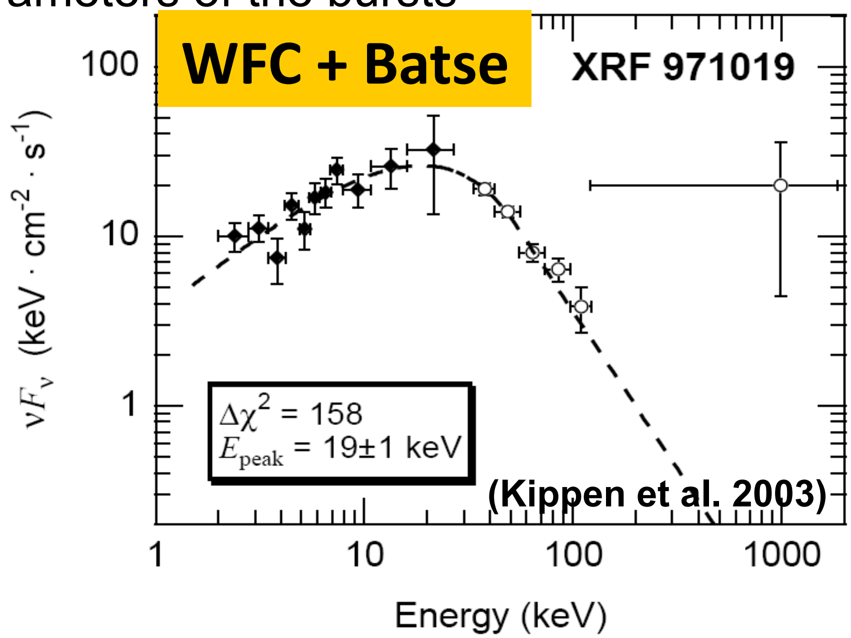


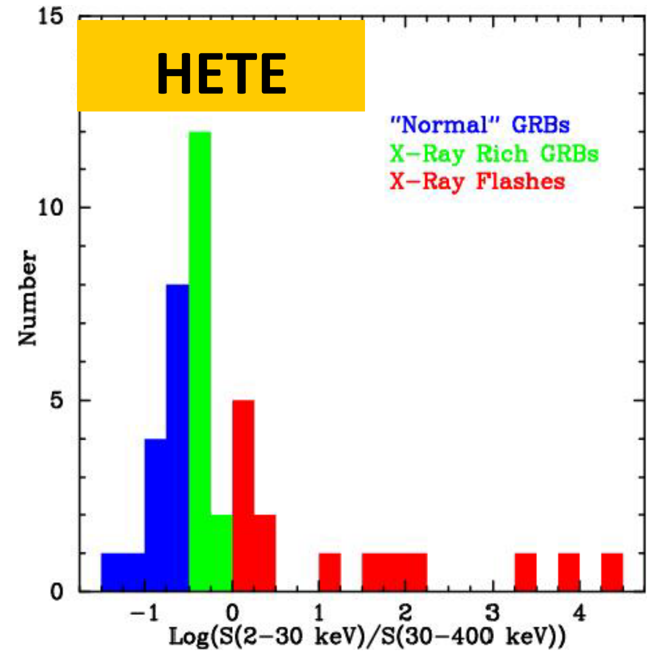
Energy Bandwidth (1/3)

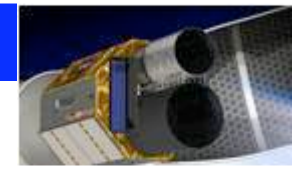
Better low energy extension than BAT means a significant increase in number of afterglows due to detection of XRFs and high-z (>5) GRBs

- ❑ HETE finds that about 1/3 of the GRB events are XRFs

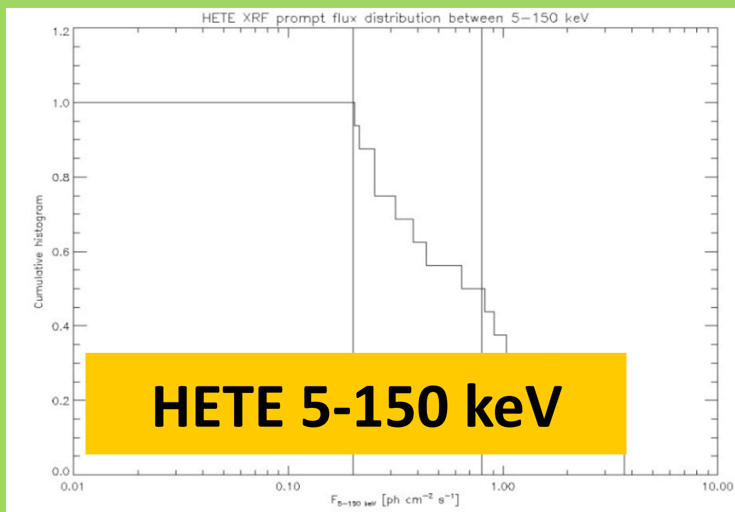
- ❑ a low energy thheshold will also help better determination of spectral parameters of the bursts

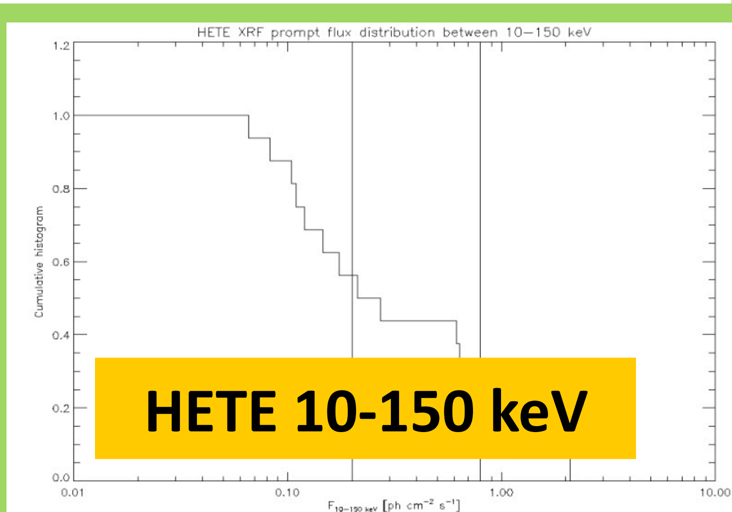






Energy Bandwidth (2/3)

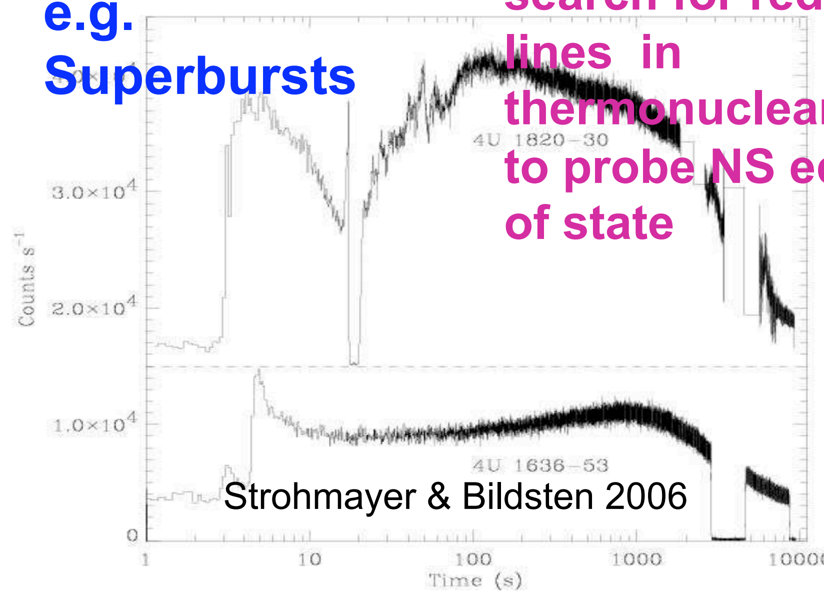


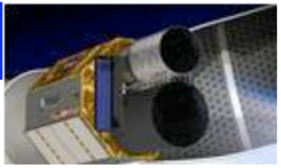


- ❑ The number of XRF detections doubles by varying LE threshold from 10 to 5 keV
- ❑ the lowest possible threshold is also a benefit for type-I bursts detections (SNR is a factor ~3 better)

e.g. Superbursts

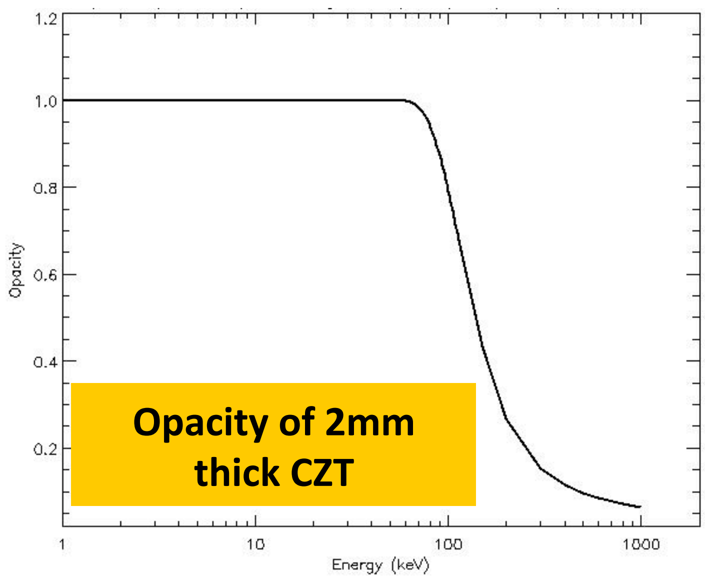
search for redshifted lines in thermonuclear bursts to probe NS equation of state

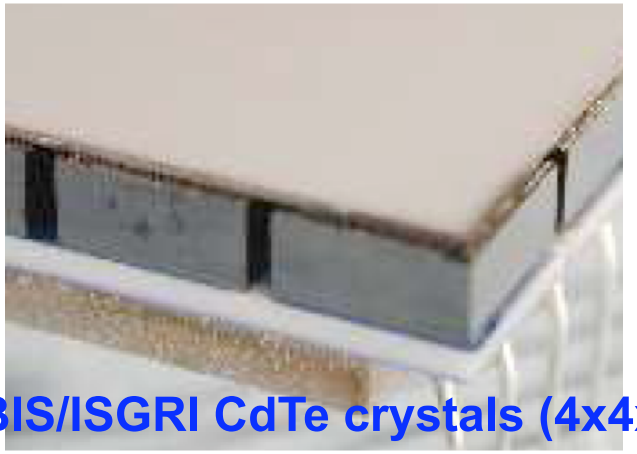




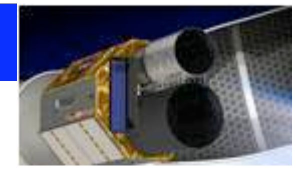
Energy Bandwidth (3/3)

- Imaging is required mostly for transient localization: the priority for TED is to maximize the SNR of a detection
- For prompt GRB spectra a value of high threshold of ~200 keV for effective spectroscopy seems appropriate
- a CZT thickness of 2mm is considered

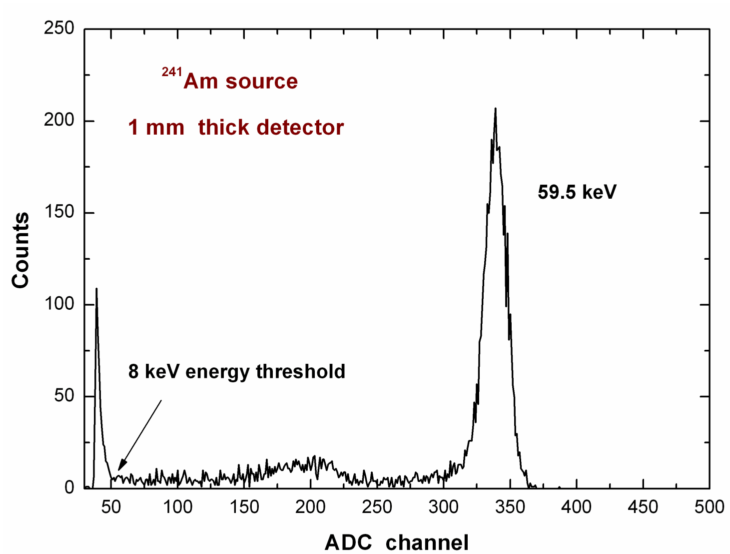


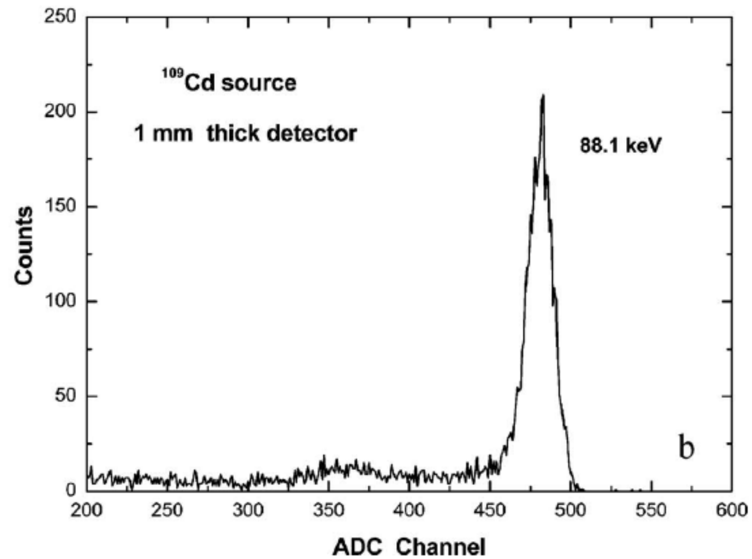


IBIS/ISGRI CdTe crystals (4x4x2 mm)



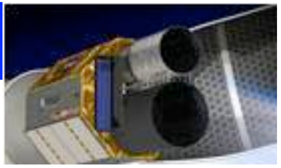
Spectral performance of CZT detectors





Spectrum for a 1 mm thick 16x16 CZT pixel detector (0.5mm pitch), obtained at 25° temperature (from Abbene et al., J.Appl. Phys. 2009).

- The readout is based on a custom low noise, low power ASIC readout.
- The energy resolution is 5.8% at 60 keV and 3.9% at 88 keV
- Similar results for 2mm thick detectors

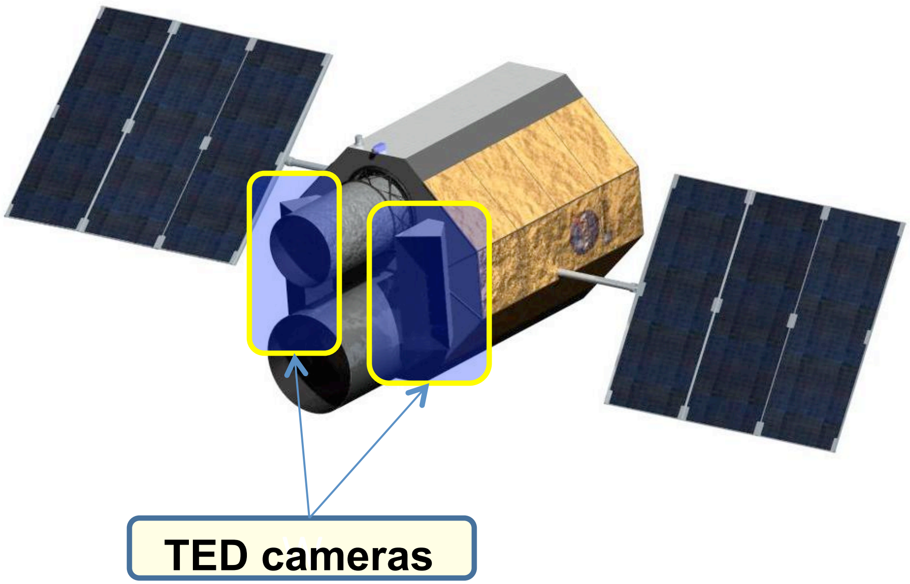


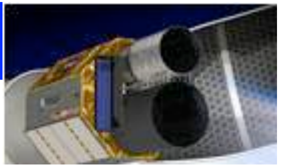
Design drivers and adopted configuration

- **Angular resolution** similar to IBIS and BAT, to ensure the required location accuracy for repointing (4’)
- **FOV** as large as possible to match the required 3 sr, for bright burst detections
- **Off-axis detection area** large enough for large sky coverage with good SNR

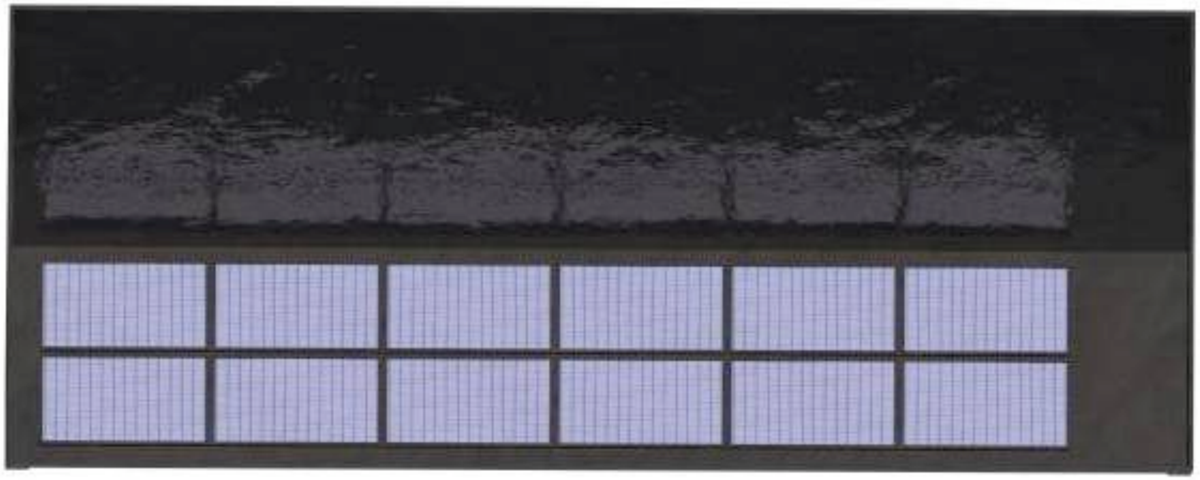
Design based on 2 cameras with viewing axis slightly tilted (28°) respect to the X-ray telescopes: good effective area on axis while ensuring a large sky coverage

Coded masks are located at 40.5cm from detectors





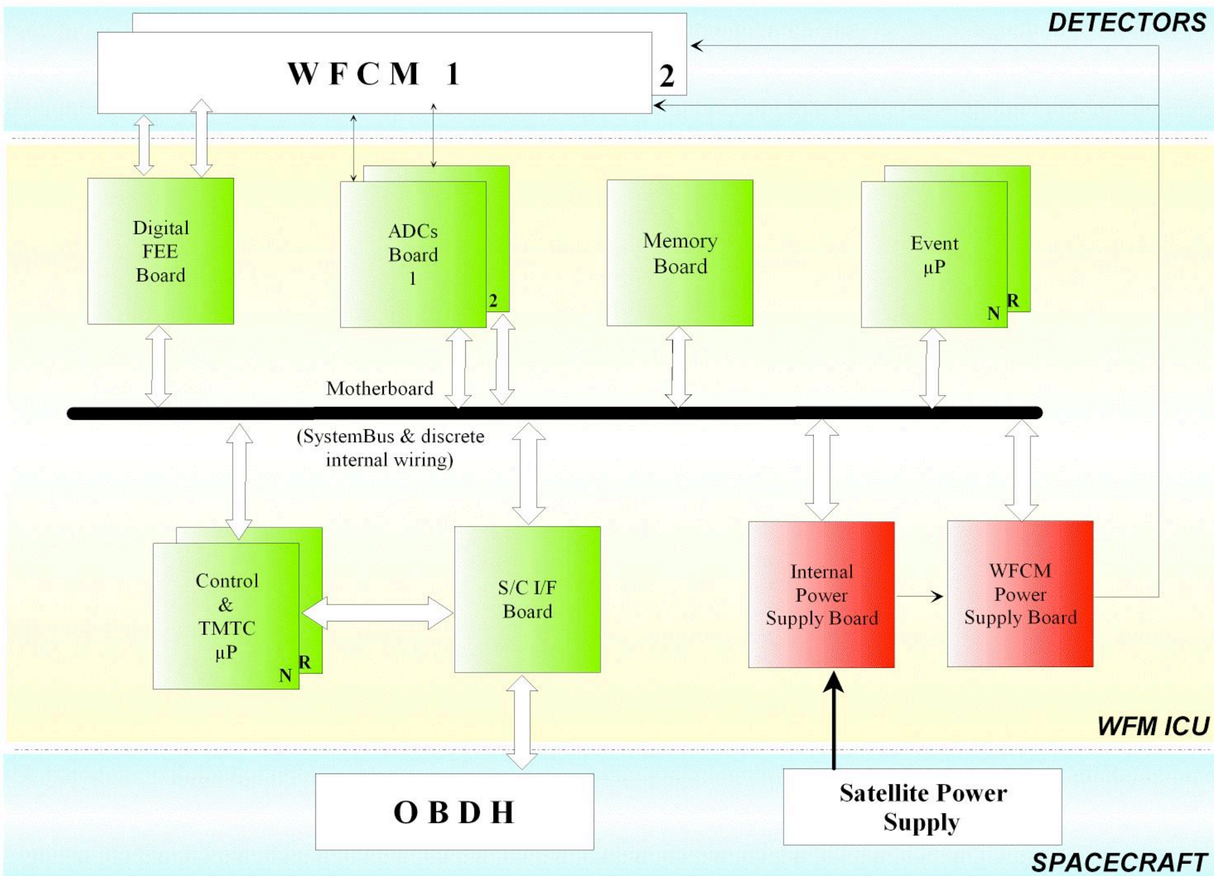
Design of one TED detector unit



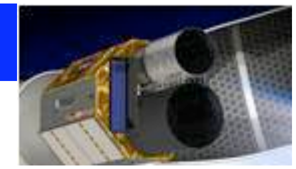
One TED detector as seen by the direction parallel to the optical axis of the X-ray telescopes . The active detection area of TED is **1790 cm^2** for one camera

- **12 CZT modules**
- **1 module: 16x8 crystals, of size 10.8x10.8 mm^2**
- **each crystal is an array of 4x4 pixels (a la IBIS) , of size 2.7x2.7 mm^2**
- **Modules are assembled on spider structure, mechanical housing with egg-crate, 4x4 crystals each cell**

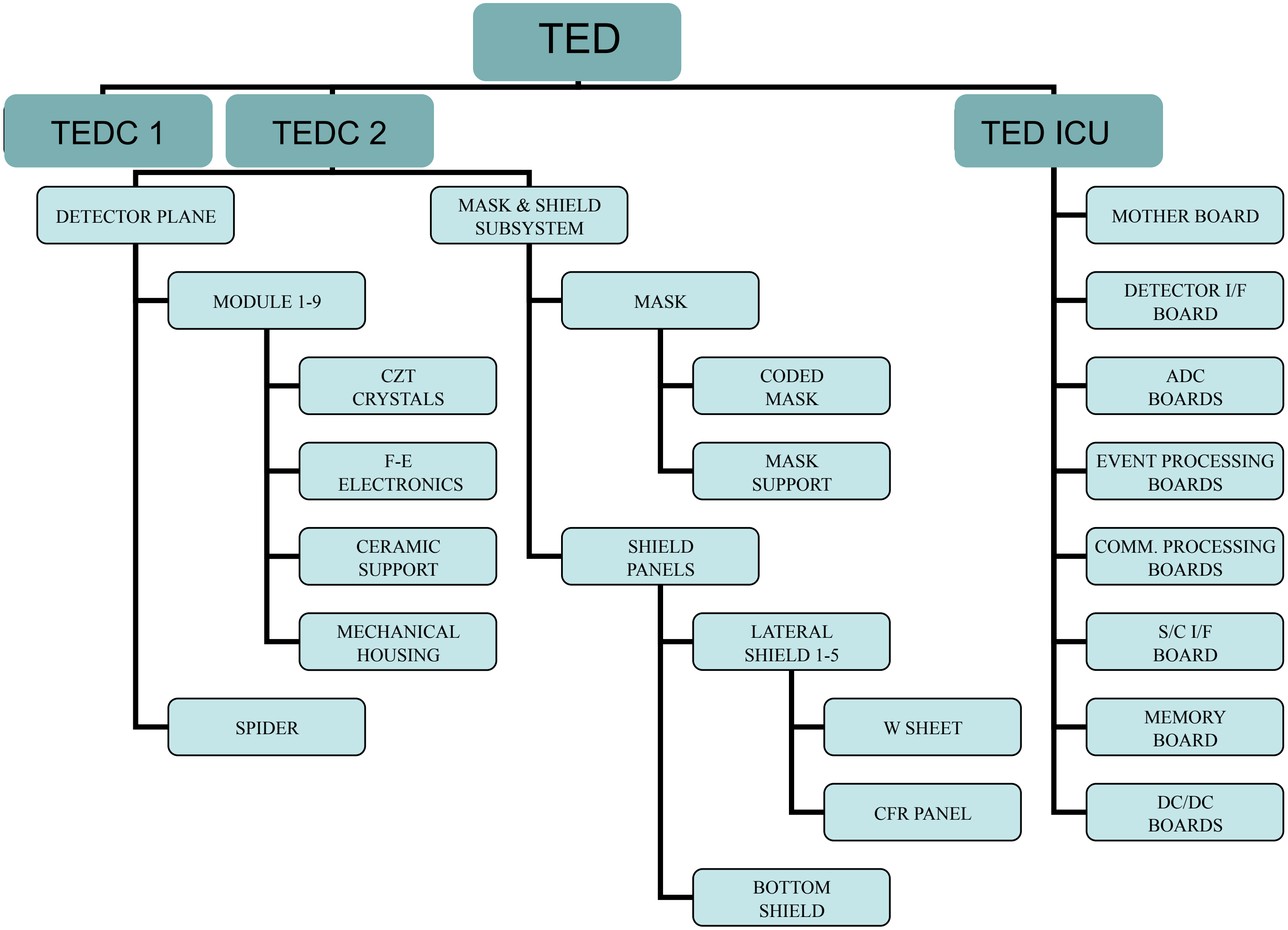
Instrument Control Unit

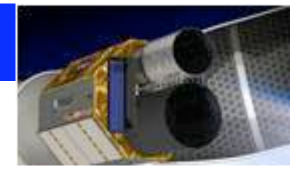


ICU functional diagram. A single ICU is serving the two detector units. Also indicated are the S/C Interfaces for both data/commands and Power supply.



Instrument Hardware Tree

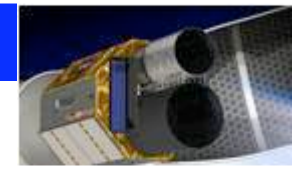




TED Performance summary

Parameter	Require-ment	Goal
Resolution at 100 keV	5 keV	3 keV
Field of View	2.8 sr	3 sr
Array size (pixels, one camera)	24,576	98,304
Energy range (keV)	8–200	5–300
Effective area, 20-50 keV (cm^2)	1500	1500
Angular resolution (FWHM)	34’	17’
Source location accuracy (10σ)	4’	2’
Min. count rate (background) [c/s]	2500	2500
Peak count rate [c/s]	7000	7000
S/W processing time	20s	10s
Continuum sensitivity (1s,15-150 keV; ph/cm^2s)	0.4	0.4

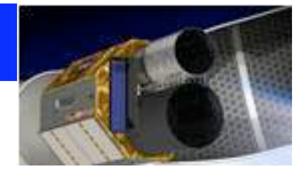
The TED pixel size (2.7mm) can easily be improved a factor 2, the power needed have to be assessed (baseline 0.8mW/ch). 0.2 mW will allow 2 arcmin PSLA



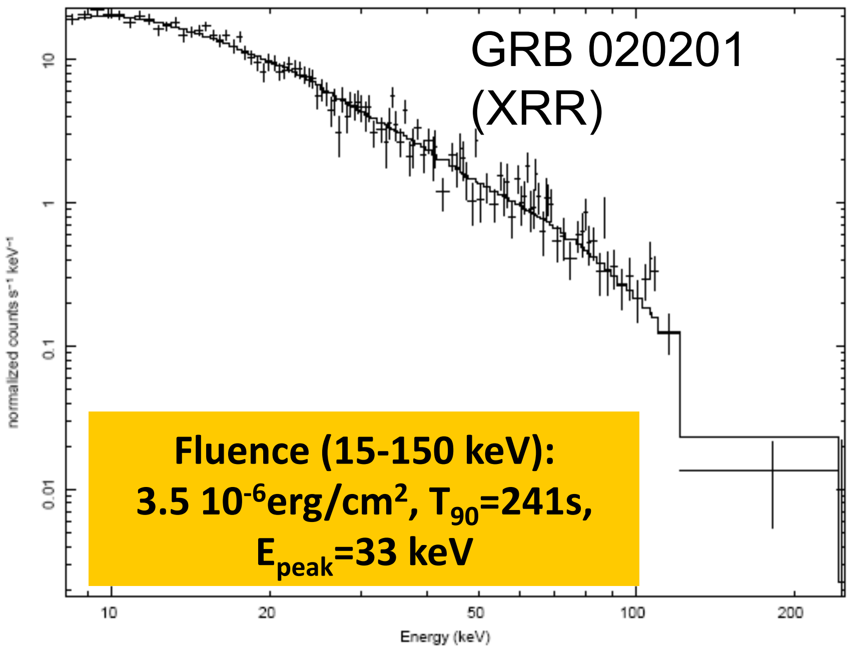
Mass and Power

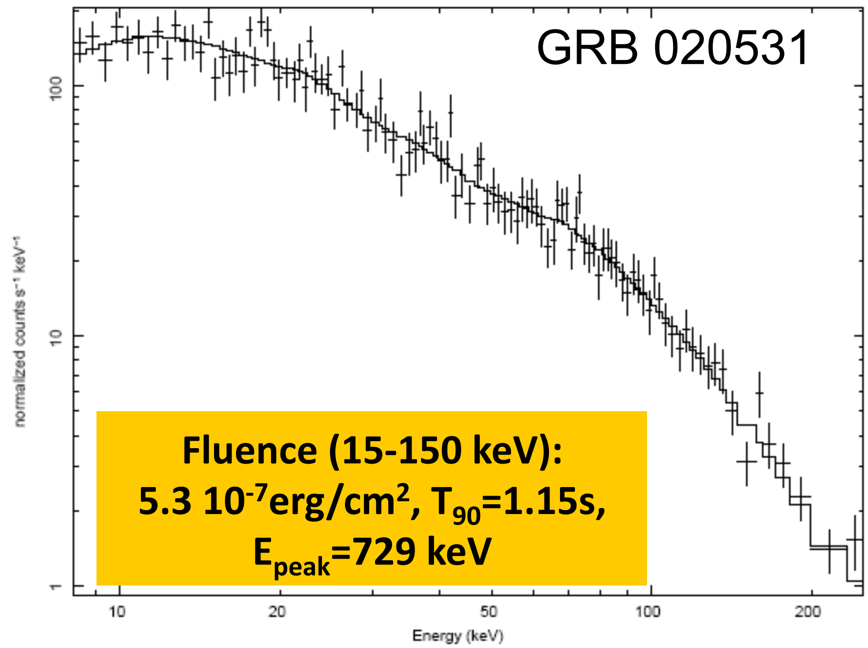
Unit	CBE Mass (kg)	CBE Power (W)	TRL 2009
TED-1 detector	18.8	22.1	6
TED-1 mask	9.8		5
TED-1 shields	22.8		7
TED-2 detector	18.8	22.1	6
TED-2 mask	9.8		5
TED-2 shields	22.8		7
ICU	8.1	83.2	7
Total	110.9	127.4	
w/ margin	144	165	

NOTE: Lateral shields are W, graded shields could be adopted



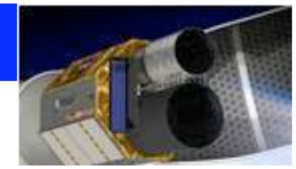
Simulation of GRB spectra



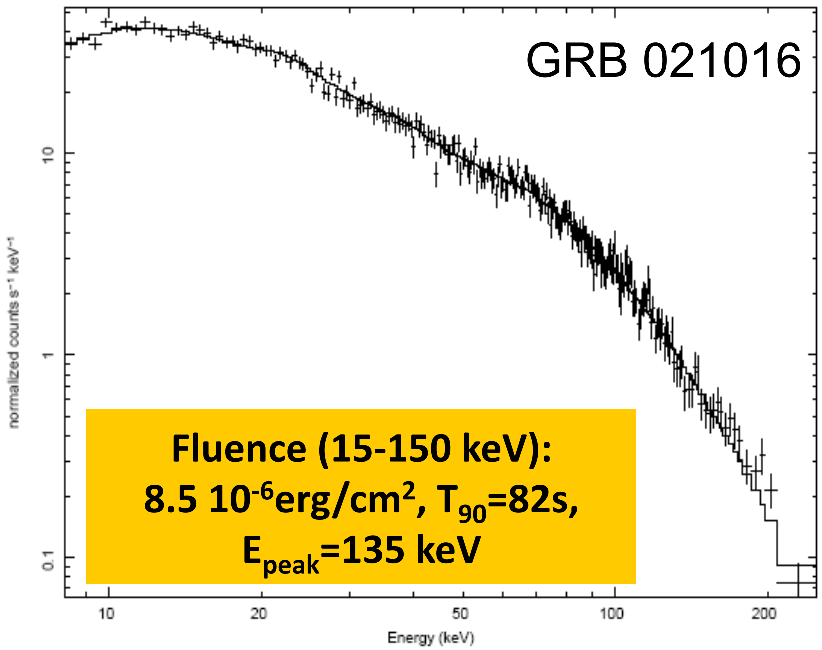


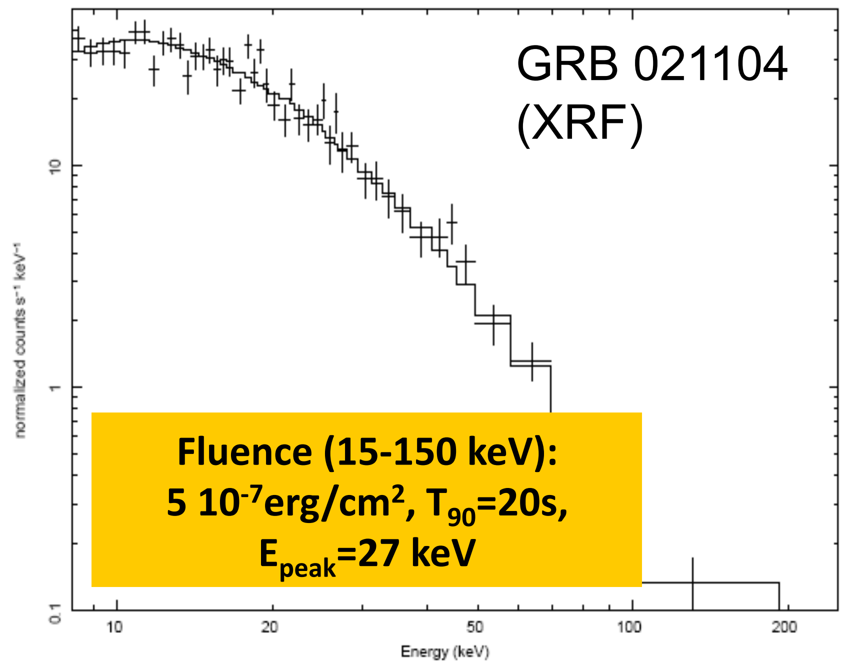
Simulated spectra of GRBs using cutoff PL, spectral parameters from Barraud et al 2003 (HETE-2 data)

- ❑ All bursts assumed at 30deg from on-axis of the X-ray telescopes
- ❑ GRB 020201 is a long lasting, X-ray rich GRB



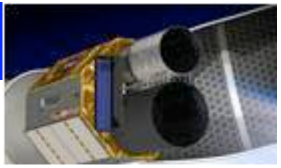
Simulation of GRB spectra



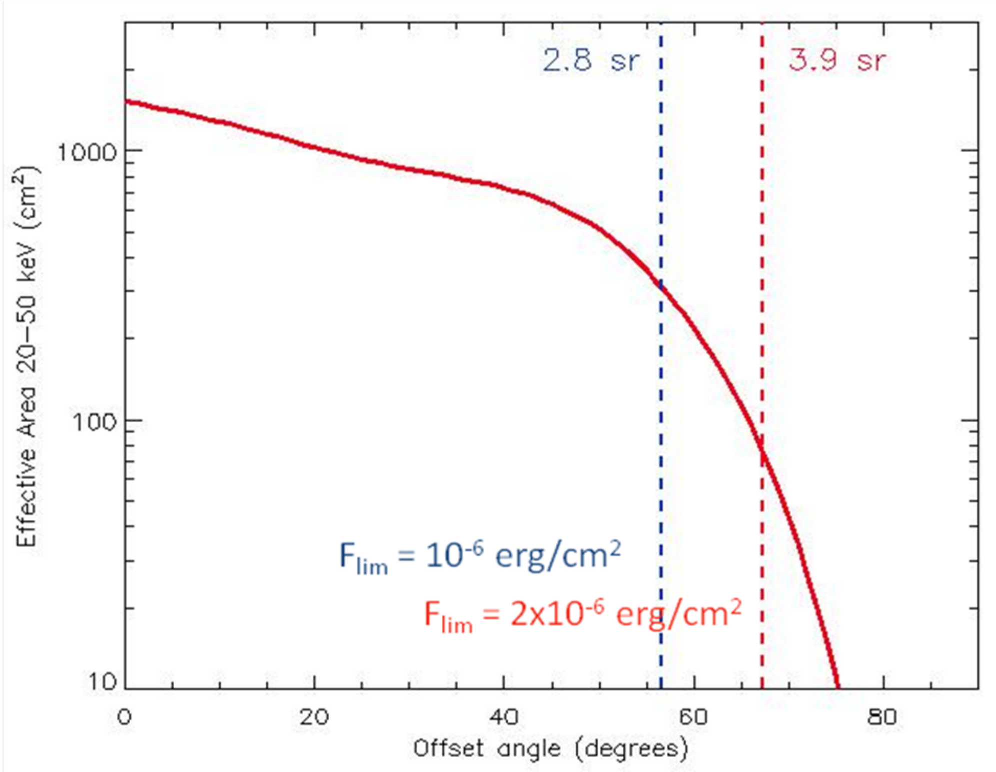


Simulated spectra of GRBs using cutoff PL, spectral parameters from Barraud et al 2003 (HETE-2 data)

- All bursts assumed at 30deg from on-axis of the X-ray telescopes
- GRB 021104 is a (rather faint) XRF



Effective sky coverage of TED



Effective area of TED (2 units) vs off-axis angle with limiting burst fluences for two different FOV limits.

The sky coverage is as large as 2.8sr. For bursts brighter than 2×10^{-6} erg cm^{-2}, the FOV is increased to 3.9sr.